Arlindo Circulation:A Study of the Indonesian Sea's Circulation and Mixing. The IES Component

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LONG TERM GOALS

The Arlindo Project ("Arlindo" is an acronym for Arus Lintas Indonen, meaning 'throughflow' in Bahasa Indonesian) is a joint oceanographic research endeavor of Indonesia and the United States. Arlindo has as its primary goal to study the circulation and water mass stratification within the Indonesian Seas in order to formulate a thorough description of the source, spreading patterns, inter-ocean transport and dominant mixing processes.

OBJECTIVES

The main fieldwork consists of the deployment of current meter moorings, some of them equipped with temperature pods, inverted echo sounders, pressure gauges and hydrographic surveys including acoustic Doppler profiling and tracers. This Program is to carry out the IES component of Arlindo. As part of this grant, three inverted echo sounders equipped with pressure gauges are to be deployed along the main axis of the Makassar strait bracketing the current meter mooring to measure: the meridional throughflow by monitoring the pressure gradient along the strait, and to study internal waves and tides at the Makassar strait.

APPROACH

One of the parameters that will be measured with the PIES is the difference of pressure between sites. In a narrow channel in which the effects of rotation can be neglected, all of

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the flow is in the direction along the channel. The condition for the effects of rotation to be negligible is that the width of the channel is small compared to the Rossby Radius of deformation (R). Due to the proximity to the equator, the Coriolis parameter is almost zero and R is very large. Therefore, it can be assumed that all of the motion will be along the channel. The equations that govern this motion are basically the Bernoulli equation and the mass conservation equation. In first approximation, these equations can be solved for the total velocity, V, and a relation between the difference in pressure and the transport can be obtained. Indeed, all that can measured with a PIES array is the pressure variability (these are free-fall deployed instruments and the depth at which they were deployed is unknown). In order to recall this pressure variability to velocity, all that is needed is a measurement of the current at one point. A current meter mooring will be deployed between the PIES and the mean current at the bottom will be used as the mean barotropic component. In addition, ADCP haul mounted measurements between the station will be obtained to provide another independent variable to calibrate the instruments.

WORK COMPLETED

The 1996 Baruna Java cruise

The Arlindo Circulation deployment cruise took place from the Indonesian research ship, Baruna Jaya I during November 1996. The location of the stations occupied during the cruise are given in Figure 1. Four PIES were deployed during this cruise. Their locations are shown in the insert of Figure 1 by black squares numerated from 1 to 4 (see insert, Figure 1). In addition, 2 current meter moorings, MAK-1 and MAK-2 were deployed in the strait. They are shown as triangles numerated 4 and 5 in the insert of Figure 1. Three PIES are placed in a line along the channel axis, spanning 2 degrees in latitude. A fourth PIES was placed at the MAK-1 as part of the western mooring site in Makassar, at about 7 nm northwest of PIES-2. The PIES at MAK-1 will allow direct comparison of the IES average water column temperature with the T-pods measurements of internal waves and tides, and with the current meter response to the change in sea level as measured by PIES 1, 2 and 3. Additionally, it will provide redundancy for the middle IES, increasing the chances of getting the along-channel pressure gradient. ADCP measurements were collected along the PIES line twice in the way down during the deployment of PIES 1, 2 and 3, and in the way back up in a line 3 nm to the west, which passed through the mooring #1. CTD stations were obtained at the site of deployments, for further calibration of the time series. Instruments will be recovered during February 1997. CTD stations are indicated as circles (Figure 1).

The new PIES

The instruments used during the experiment were borrowed from another program because funding started right before the cruise and there was not time to build the instruments. During this second year of funding, and while the instruments remain deployed, three PIES are under construction.

The Inverted Echo Sounder design is being updated to take advantage of many advances in electronics, controller and data storage capabilities, and with a major goal being cost reduction per instrument. This task is undertaken in conjunction with Dr. Randy Watts (University of Rhode Island.) Other goals are improved stability of the period-counter for the pressure sensor, longer deployment capability (3-5 yr.), simplified two-way half-duplex data-telemetry, and (optional) solid-state data storage. The old design cost $20-24K commercially, and now many of its components are obsolete or hard-to-find. The target cost is $6K (with pressure adding $4K). The first couple of prototype and production runs will cost more because of all the new engineering-design expenses. To achieve a nearly six-fold cost reduction (while retaining essential functionality and reliability) is ambitious, but attainable. A new microprocessor and FSK telemetry capability can replace several expensive old sub-components, the digital tape recorder, the release-decoder electronics, former separate cards for the pressure/temperature counters, and numerous other features. The power tree and voltage regulators are being simplified to remove former redundancies. We are evaluating alternative pressure-housings and four much less expensive acoustic transducers for directionality and efficiency. The heart of the measurement -- the echo detection circuits -- will retain the same design, because it has a highly successful track record.

All the above electronics functions (echo detector, voltage regulators, power amplifier, micro-controller, solid-state memory, pressure/temp counter, high-stability quartz oscillator, FSK send/receive) are now designed, and all circuits now fit on a single 12" prototype printed circuit board, which has been produced and is undergoing bench-tests. Software development is a major task for the system; development is all in "C" language and downloaded to the 68332 microprocessor; the overall flow chart and many subsystems are now programmed, but much work remains. The new acoustic transducer has been preliminary selected after extensive testing; a write-up will solidify our choice. Thus far all subsystems are working well. The FSK two-way telemetry communication is the component that most requires testing in real deployment conditions, for immunity to multipath problems, etc. We are hoping to be ready for deep water testing off Eleuthera before January 1988.

IMPACT AND IMPLICATIONS

The moorings deployed during Arlindo (PIES and current meters) will be the first ones to be deployed in Indonesian waters. The data to be collected will provide the first time series of the through flow across the Makassar strait, the major conduit for the exchange between the Pacific and Indian Oceans. This is a critical parameter to understand inter-ocean exchange. Inter-ocean transport within the Indonesian Seas is the primary means of exporting excess fresh water from the North Pacific Ocean. The efficiency of this transfer dictates to a large measure the meridional overturning of the Pacific and Indian Oceans and perhaps of the global thermohaline “conveyor belt." These processes are relevant to climate issues. In particular, to the El Niño phenomena as it allows a transfer of warm water in the eastern Pacific into the Indian Ocean, adjusting the volume of the warm pool.

TRANSITIONS

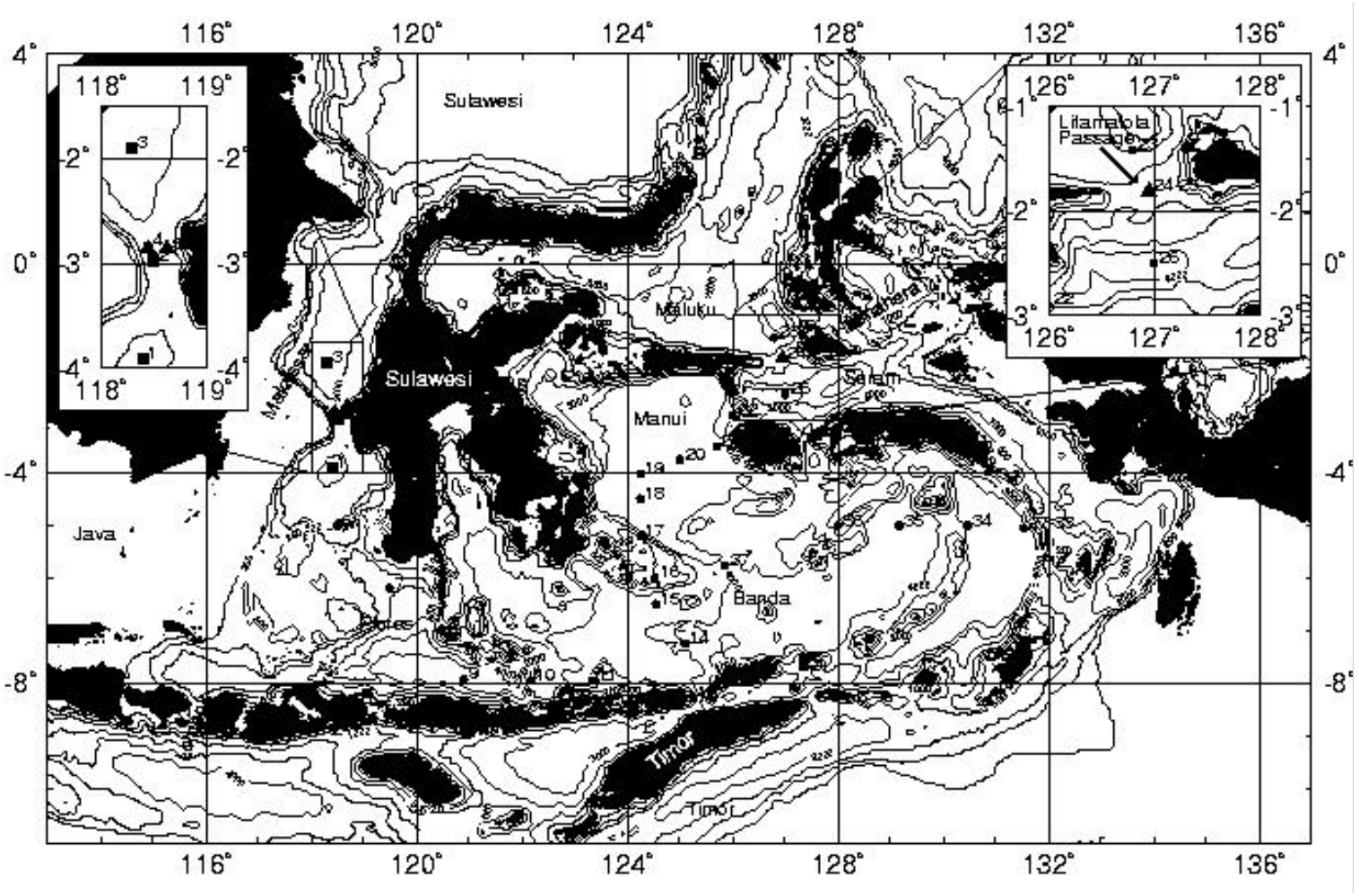
A substantial contribution will be made to the creation of a new generation of PIES or IESs. The price of the instrument will be lowered while the detection capabilities will be improved. This will permit the deployment of larger and more confident instruments. It is expected that large arrays of the new instruments will be used in future programs. The PI already submitted a proposal to the National Science Foundation to use the new instruments as part of a large array to be deployed in the North Brazil Current.

RELATED PROJECTS

Thsi program is a component of the NSF and ONR funded Arlindo Circulation Program (Arnold Gordon, US Chief scientist). Components of Arlindo Circulation are: Current meter moorings (D. Pillsbury, PI) and Temperature pods (A. Ffield and S.L. Garzoli, co-PIs); PIES (S. L. Garzoli, PI); CTD oceanographic stations (A.L. Gordon, PI), and tracers (R. Fine, PI); shallow Pressure Gauges (N. Bray, PI); large scale remote sensing (C. Koblinski).

REFERENCES

The web address for Arlindo is:
http://www.ldeo.columbia.edu/physocean/proj_AM.html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